ROCK LINED CHUTES

Rock lined chutes are generally economical structures for grade stabilization when design discharges are not large.

The use of rock for erosion protection is dependent upon the ability of rock to resist erosion more than soil. Just as it is recognized that there are various types of soil, similarly there are various types of rock, and the statement "rock is rock" is not necessarily the case when the rock is expected to possess certain properties for a particular use. Not all rock is durable enough to withstand the forces of weathering and erosion for an extended period of time.

Rock for riprap should be dense, sound, and free from cracks, seams, and other defects conducive to accelerated weathering. The rock should not be slabby; i.e., the greatest dimension must not be more than three times the least dimension. The weight of the rock particles, and therefore the rock size, is important so that the rock particles can resist the erosive force of moving water. Proper gradation is necessary to prevent the formation of voids within the placed riprap which could occur through removal of smaller and lighter pieces of rock by the erosive forces of the moving water.

Durability of rock is dependent upon various factors:

1. Type and mineralogy of the rock:

Bedrock - In Indiana there are four major types of bedrock: sandstone, shale, limestone, and coal. Of these, only some limestone is normally suitable for riprap. Dolomite is a rock similar to limestone, and for the purposes of this section the term "limestone" will include dolomite. (Dolomites are found in the older rocks of Indiana in the eastern part of the state; limestones are found across the entire state, but more abundant in southern Indiana.)

Chert is a microcrystalline form of the mineral, quartz (SiO_2). It is generally found as nodules scattered through limestone. Chert is brittle and causes the limestone to deteriorate making it unsuitable for riprap. It may be recognized by its hardness (it cannot be scratched by a knife), nodular appearance (sometimes), and it will not effervesce in muriatic acid (HCl). Another name for chert is flint (dark green to black coloring).

Pyrite (FeS_2) is a metallic yellow mineral also known as Fool's Gold. Pyrite is scattered through some limestones. Some pyrite is unstable, breaking down and forming sulfuric acid, which weakens the rock and causes acidic conditions in streams.

Sandstone, under certain conditions, has been found to be suitable for use as riprap. Blocks may case-harden on the outside if they are stockpiled for a period of time prior to use. Most sandstone, however, will not case-harden and should be avoided.

Shale is unacceptable for use as riprap. The clay minerals that comprise shale absorb water during the weathering process, expand and cause the rock to slake and break down. A high percentage of clay minerals within limestone will cause the rock to deteriorate.

Glacial boulders, found in fields, may be suitable for use as riprap, but their quantity is generally too limited. The best boulders are those of igneous and metamorphic rock.

2. Structure of the Rock: Rock structure refers to the bedding and overall appearance.

Sedimentary rocks are deposited in horizontal layers (beds). The separations between the beds are called bedding planes. Massive beds of limestone are needed to produce heavy blocks. One cubic foot of limestone, which has a bulk specific gravity of 2.6, will weigh 162 pounds.

Shale is sometimes found as very thin dark layers ("partings") within limestone. The limestone will separate along the shale partings when blasted, forming slabs. Weathering occurs along the partings with subsequent rock deterioration.

Joints are vertical or inclined cracks, naturally occurring in the rock. Closely spaced joints will affect particle size.

3. Texture: Texture refers to the shape and arrangement of mineral grains within the rock.

Limestones generally have irregularly shaped grains with interlocking boundaries. Individual grains of sandstone are bound together with cement, and it is the weakness of this cement that makes most sandstone unsuitable.

Shales do not have cement; the clay particles are merely pressed together by pressure.

Many rocks have pores (vugs) which may be arranged in bands. Large vugs appear to have no effect on durability; small pores which are arranged in bands can hold water and crack the rock when the water freezes.

4. Weathering: Given enough time, the agents of weathering break rock down and change it into soil. In some areas subsurface water has moved through the bedrock and weathered it prior to excavation.

5. Actions of man: Rock is normally available for riprap only from sources where the rock is excavated for sale (quarries). Most quarries are set up to produce aggregate for concrete or road materials. Riprap sales are generally incidental to the primary quarry operation. Quarries normally use large explosive charges in blasting to keep the amount of crushing needed to produce aggregate to a minimum. This results in a high proportion of small particles on the blast pile ("shot rock"). If the beds are thick enough, blasts do produce some large blocks of a size suitable for riprap. Oversize blocks are sometimes broken up by means of a heavy iron weight ("headache ball") dropped by a crane.

Some quarries separate the larger blocks into a riprap stockpile. Most large riprap is merely "shovel loaded" from the blast pile into a waiting truck, without sorting out the finer sizes. Rock loaded by a bucket with prongs welded onto the bucket, or rock that is passed over a set of spaced rails (grizzly) will lose the finer particles and improve the gradation. Some riprap is produced from the rock after it passes through the primary crusher.

In Indiana, good quality rock for riprap can be obtained by specifying that the rock must meet the requirements of "Class A Coarse Aggregate" as defined by the Indiana Department of Highways specification 903.02.

DESIGN ELEMENTS

Rock Lined Chutes are installed under Practice Code No. 410 (Grade Stabilization Structure).

Design Flow:

The required design storm frequency is determined from Table 1 in Technical Guide Specification 410, Grade Stabilization Structure. In most instances, the total capacity design storm frequency should be used since it is difficult to provide an emergency spillway. A drainage curve capacity should not be used. Rock lined chutes are not normally designed for flows exceeding 150 cubic feet per second (cfs).

Rock Size:

Rock size for chutes is expressed as the d50 size in inches (50% maximum passing by weight). To provide an economical design, rock available from local quarries should be used. The size stone likely to be available and installed should be determined and used to design the rock chute. See Figure IN-6-10 for weights of equivalent spherical rock size.

Rock Lining Roughness:

The roughness, or "n" value, of the rock lining varies with the rock size and the depth of flow. Figure IN-6-7 is a graphic representation showing these relationships.

Flow Velocity:

Allowable velocities for various rock sizes used in rock lined chutes are shown in Figure IN-6-8. These allowable velocities are 90% of the values accepted by the U. S. Department of Transportation, Federal Highway Administration, for water flow against rock riprap.

Bottom Width:

The bottom width (b) of the chute should be sized to fit the site. Consideration should be given to the method and type of equipment that will be used to place the riprap.

Side Slopes

The chute side slopes (z) may be as steep as 2:1, but are normally 3:1.